Snowmass Summary Report for AF5: Accelerators for Rare Processes and Physics Beyond Colliders, Executive Summary

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The mandate of the AF5 Working Group was to investigate "Accelerators for Rare Processes and Physics Beyond Colliders". This turned out to be something of an illusive topic, as in most cases, the accelerator needs of such experiments were already being investigated by their proponents. There was also significant overlap with other working groups within the Accelerator Frontier, specifically AF2 (Accelerators for Neutrinos) and AF7-T (Accelerator Technology - Targets and Sources).

We elected not to investigate experiments that are entirely parasitic to other programs, such as neutrino beam dump experiments and high η detectors at colliders, as we felt that those experiments themselves were not driving the accelerator choices.

In the end, we chose to divide our report as follows:

- Optimum exploitation of the PIP-II Linac at Fermilab. The PIP-II Linac is a superconducting linear accelerator that will increase the injection energy of the Fermilab Booster from 400 MeV to 800 MeV. The primary motivation for this is to increase the total proton power to the high energy neutrino program, specifically the DUνE Experiment; however, that will only use about 1% of the beam available from linac, which can provide a maximum of 1.6 MW at 800 MeV.

  Individual experiments, like Mu2e-II, have come forward with detailed proposals for the 800 MeV PIP-II beam, and other experiments but as yet there is no coherent plan for beam distribution and beam usage. Other muon experiments like $\mu \to e\gamma$and $\mu \to 3e$ could also be carried out at this facility, although those proposals are not yet as developed. Although it is not high energy physics, a surface muon program has been proposed as well.

  To increase the sensitivity of the search for muon to electron conversion, an FFA has been suggested to produce pure muon beam with a narrower energy and time spread. This would require a new bunch compressor ring to accumulate beam from the PIP-II linac and extract it in intense bunches at rates rates of 100-1000 Hz. Such a compressor could also serve a more extensive experimental program. In particular, it could drive a set of dark sector searches based on beam dumps.

  We feel that the because of the time of the current Snowmass process relative to state of construction and planning for the PIP-II project, it can and should take a leading role in developing the experimental program.

- Beam dumps support a broad range of experiments, generally searching for dark sector or other rare particles. These generally don't have demanding beam requirements beyond the total power and our role in this area will be to catalog the capabilities of various facilities, as these experiments use a wide range of beam energies

Proton beam dump experiments range from energies in the GeV range, such as the RedTop Experiment at the CERN PS to the SHiP and NA62++ experiments, which use the 400 GeV beam from the CERN SPS.

Electron beam dump experiments range from the 100 MeV beam for the DarkLight Experiment at JLab to the 11 GeV BDX experiment at the same lab. Because electron beam dump experiments have no beam quality requirements beyond total beam power, they have potential as an early application of proton or laser wakefield acceleration, and charting a course for this line of research is another topic that should be discussed at Snowmass.

- Other opportunities. In this section, we will summarize diverse accelerator physics issues related to specific fields of experimental goals, which are not automatically addressed in the quest for high energy or high intensity. Of particular interest in this area is the Belle-II experiment at KEK, which has recently broken luminosity records.

  Storage rings for electric dipole moment (EDM) measurements also involve very interesting physics problems, particularly electrostatic storage rings of the sort that have been proposed to measure the proton EDM.

- Finally, we will discuss synergistic activities with other R&D areas. This section will highlight areas of technological development that are primarily being developed for other areas of high energy physics which can also benefit BSM searches. These include overlaps in target development with ongoing R&D for neutrino or muon experiments, powerful magnet development for “light through walls” experiments, and high Q RF development which in this case is primarily for axion searches.